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ABSTRACT

A study examined the effects of pictorial and verbal illustrations on the initial learning and long term retention of written instruction. Subjects were eighth and ninth grade students randomly assigned to one of two text conditions (literal or analogous instructions) under one of four pictorial conditions (no picture, functional drawing, expressive drawing, or functional plus expressive drawing). There were 14 subjects in each of the eight conditions. Subjects read texts according to their respective treatment conditions, then performed a sequence of five manipulations outlined in the instructions. Those who reached criterion on this task were evaluated on the same task without instructions 10 days later. Finally, they were asked to relate how they had remembered the initial set of instructions. Factorial analysis yielded no significant effect for either the type of text or the interaction between type of text and picture condition; however, ANOVA indicated a significant effect for type of picture. A post-hoc test revealed that subjects exposed to pictures significantly outperformed those in the no picture condition. A t-test indicated that subjects who had read the analogous instructions remembered more than did those who received the literal instructions. The results suggest that readers are more successful in completing instructions when pictures are provided, and that while analogous text does not seem to facilitate initial learning of instructions, it does enhance subjects' ability to retain information over time. (FL)

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Facilitative Effects of Analogies and Illustrations on Understanding and Remembering Written Directions

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ABSTRACT

The present study was intended to examine the effects of pictorial and verbal illustration on the initial learning and long-term retention of written procedural instructions. Eighth and ninth grade students were randomly assigned to one of two text conditions (literal instructions or analogous instructions) under one of four pictorial conditions (no-picture control, functional drawing, expressive drawing, or functional plus expressive drawing). The design allowed for eight treatment conditions each consisting of 14 subjects.

Data were collected on two occasions. On the first occasion, subjects read texts according to their respective treatment conditions and were then asked to perform a sequence of five specific manipulations outlined in the directions. Subjects who reached criterion in this initial phase of the experiment were evaluated on the same manual task (without directions or illustrations) after a 10-day retention interval. As a final measure, subjects were required to verbally relate how they had remembered the initial set of instructions.

For the initial phase, a 2 (Text) X 4 (Picture) factorial analysis of variance procedure yielded no significant effect for either the type of text independent variable or for the interaction between type of text and the picture conditions. The ANOVA did indicate a significant effect for type of picture. A post hoc test revealed that subjects exposed to pictures of any kind significantly outperformed those in the no-picture control condition. No differences were observed between functional, expressive, or combined levels of pictorial representation. In all, 24 subjects successfully completed the manipulations, 12 in each text condition.

For the second phase, a t-test indicated that subjects who had initially read the analogous instructions remembered more than those who received the literal instructions. All of the subjects in the analogous text condition reported using the analogy as an aid to recall.

The data suggest that readers are more successful in completing instructions of manual operations when pictures are provided and that analogous text does not seem to facilitate initial learning of these instructions. Analogous text does, however, seem to enhance subjects' ability to retain procedural information over extended periods of time.

The purpose of this study was to examine the differential effects of pictorial and verbal illustration on clarifying written procedural instructions and fostering memory of them. Although illustrated procedural instructions are in extensive use, research has produced but scant evidence that illustration, either pictorial or verbal, enhances understanding and memory of them. Stone and Glock (1981) found that pictorial illustration conveys spatial information more effectively than does unillustrated prose instructions, and Beiger (1982) concluded that pictorial illustrations are effective in procedural instructions if the pictures help fill in operation and contextual information as well as spatial information. Research on procedural texts has yet to report on verbal illustration, although the relevant literature on prose learning research suggests overlapping and perhaps complementary functions of pictorial and verbal illustration. Mayer (1975) found that analogies as well as schematic drawings improved readers' interpretation of a passage on computer operations, but he drew no conclusions about the differential contributions of either. Royer and Cable (1976) found that both analogies and illustrations facilitated recall on a transfer task, but their study did not differentiate pictorial illustrations from analogies in their effect on readers' performance.

Schallert (1980) asserts that verbal illustrations such as analogies are like pictures in that they frequently convey meaning through the vehicle of concrete referents which are likely to facilitate readers'

imaginal processing. Little is known, however, about the nature of readers' imaginal processing. To what extent is it conceptual, to what extent perceptual? To what extent are images coded in memory propositionally, to what extent do they retain percept-like qualities? And to what extent does the nature of the illustration influence imaginal processing for comprehending and remembering text?

The present research explored these questions in an experiment designed to examine the differential effects of pictorial and verbal illustration on clarifying written instructions and fostering durability of learning from them. In the experiment, eighth and ninth grade students responded to procedural instructions on tying a knot that was unfamiliar to them. Written instructions took the form of either a set of literal prose instructions or a set of prose instructions embellished by a fictional circumstance whose elements were analogous to the procedures explained. The effects of these texts were appraised under four conditions of pictorial illustration: (1) without any pictures, (2) with functional line drawings, (3) with expressive line drawings, and (4) with both the functional and expressive line drawings juxtaposed so as to pictorially emphasize their correspondence to the steps of the knot-tying procedure. Students, who on the first data collection used the directions to tie the knot successfully, were asked to tie the knot again 10 days later.

Method

Subjects

The sample comprised 112 eighth and ninth grade students attending a public school in central Georgia. Students who were identified by their

teachers as below average readers were not included in the sample. In this way, the analysis would be less likely to be confounded by the fact that students simply could not read the texts. Participating students were assigned at random to one of the two text conditions under one of the four pictorial illustration conditions.

Materials

Materials for the experiment included two sets of written procedural instructions, one set of functional line drawings, two different sets of expressive line drawings, and a 60-inch length of cotton clothesline. Both the written instructions and pictorial illustrations were developed by the investigators and patterned after those found in typical knot-tying narratives. The written instructions described how to tie the bowline knot. In both texts, five steps were outlined: (1) form a small loop, (2) draw one end of the rope through the loop, (3) take the end of the rope behind the standing part of the rope, (4) tuck the end of the rope back down into the small loop, and (5) tighten the knot. The literal instructions introduced the bowline knot with comment on its purpose and then proceeded to explain how to tie the knot step by step. The embellished instructions introduced the bowline knot and then directed the reader to imagine an analogous fictional circumstance whose elements corresponded to the steps of tying the knot: the movement of a rabbit emerging from his hole, circling a tree, and returning to his hole, as in tying the bowline the bitter end of the line passes through a loop, takes a turn around the standing part of the line, and fits back into the loop. Three sets of four line drawings were created by the investigators. A set of functional line drawings was created to accompany the written

directions alone as well as in corresponding combination with either of two sets of expressive line drawings (Duchastel & Waller, 1979). One set of expressive line drawings was created specifically for the literal directions and one set of expressive line drawings was created specifically for the fancifully embellished directions.

Procedure

There were eight instruction-illustration conditions for which data were collected in a 2 (text) x 4 (pictorial) factorial design: Literal and fancifully embellished instructions, either not pictorially illustrated or pictorially illustrated in one of three ways--functional line drawings, expressive line drawings, or a combination of corresponding functional and expressive line drawings.

Students were observed individually in their usual English classes at interview stations situated so that other students could not view the procedure. On the days of data collection, the students were assigned quiet seatwork activities. The regular classroom teacher shuttled students to the investigators. As each student reported to the interview station, the investigator asked "Have you ever heard of the bowline knot?" While an affirmative answer would have eliminated students from the sample, none indicated knowledge of the knot. Each student was then handed a folder containing an instructional text illustrated according to treatment condition and directed to read the knot-tying instructions carefully. Upon reading the text, the subject was handed a length of clothesline

and directed to tie the bowline knot. It was made clear that looking back at the text and illustrations, if present, was permitted. Following each student's attempt to tie the bowline knot, the investigators asked how the instructions and pictures had been used, that is, what strategies were employed.

The second data collection took place 10 days later. Only subjects who had correctly tied the bowline knot in the first phase of the experiment participated in the second phase of the experiment. Each of these subjects was again directed to an unobtrusive interview station in the classroom while other students worked on a class assignment. Students were asked to verbally recall the instructions and then directed to tie the bowline knot without looking at any directions or illustrations. Following each student's turn, the investigators asked how the student had remembered to tie the bowline knot.

Scoring

Understanding written directions was operationally defined as the accuracy with which subjects followed the directions that were given. Accuracy in following directions was determined by tallying the correct manipulations made in following directions. Credit was given for manually accomplishing each of the five steps involved in successfully completing the knot. Scores ranged from a minimum of zero for no steps completed to a maximum of five for a fully-formed knot. Although start-overs were permitted, no credit was given for repeating previously-accomplished steps on successive attempts. Further, since the knot-tying procedure was necessarily sequential in nature, any manipulation peformed out of order was also not credited.

Durability of learning was operationally defined as the accuracy with which students followed directions from memory after an interval of 10 days. The method of determining level of accuracy was identical to that used for the initial observations, i.e., tallying the number of steps successfully completed in attempting to tie the bowline knot.

Results

The results of the initial data collection are displayed in Tables 1 and 2. The data collected on the first occasion were subjected to a two-way analysis of variance in order to find differences in subjects' performance across four pictorial illustration conditions across literal and fancifully embellished procedural instructions. The ANOVA procedure revealed no statistically significant interactions between any pictorial illustration condition and either type of text, $F(3,104) = < 1$, n.s. Nor was a statistically significant difference observed in subjects' performance according to the type of written instructions, $F(1,104) = < 1$, n.s. A statistically significant effect was detected across pictorial illustration conditions, $F(3,104) = 10.30$, $p < .01$. A Newman-Keuls post hoc procedure showed that subjects across all of the pictorial illustration conditions outperformed subjects who did not see any pictures, but that subjects' performance did not significantly differ according to the kind of pictures they viewed.

On the first data collection, a total of 24 subjects successfully tied the bowline knot, 12 in each text condition. Between the subjects of the two text conditions, a statistically significant difference was observed in their memory for tying the bowline knot after a retention interval of 10 days, $t = 3.17$, $p < .01$. The t-test indicated that the

subjects who had read the fanciful instructions outperformed the subjects who had read the literal instructions, $\bar{X} = 3.67$ - $\bar{X} = 2.75$. Eight of the subjects who had read the fanciful text reached criterion while only three of the subjects who had read the literal instructions reached criterion.

Upon questioning subjects who successfully tied the bowline knot from memory how they remembered to tie the knot, all who had read the fanciful instructions referred to the analogy between tying the knot and the path of a rabbit staking out its territory. One of the subjects who had read the literal instructions remembered the steps given in the instructions almost verbatim. Another successful subject who had read the literal instructions reported that he had practiced tying the bowline knot several times since learning to tie it on the first encounter.

Discussion

The results of the experiment indicate that with instructions on a manipulation task involving three-dimensional spatial relations, readers better understand and are more successful at completing them if pictorial illustration is available. With the instructions available for readers to study, analogy to a fanciful circumstance seems to make no difference in initial learning. It neither inhibits nor enhances task performance. Nor does type of pictorial illustration seem to matter. However, after a lengthy retention interval, readers who are given instructions containing analogy to a fanciful circumstance are more likely than not to remember how to accurately perform the task. These results underscore a functional difference between procedural instructions that are literally presented and those that are presented by analogy. Whereas either may be

comprehensible, especially if pictorially illustrated, analogic presentation appears to promote memory of the instructions.

That pictures enhanced performance on the knot-tying task is not surprising in spite of the relative dearth of evidence that pictures enhance readers' understanding of a text (Samuels, 1970; Concannon, 1975; Readence & Moore, 1981; Schallert, 1980; Levie & Lentz, 1982). Most of the previous research on pictures' effect on reading comprehension has not taken due account of circumstances under which pictures may be useful (Haring & Fry, 1979), the extent to which a text depends on pictures (Hayes & Readence, 1983), the contextual and spatial information pictures provide (Beiger, 1982), the overlapping of pictorial and textual content (Levin & Lesgold), and the congruency and accessibility of text and picture (Schallert, 1980). Where the research has taken these conditions into account, the finding that pictures enhance understanding of text is overwhelmingly convincing (e.g. Guttman, Levin, & Pressley, 1977; Lesgold, Levin, Shimron, & Guttmann, 1975; Levin, 1976; Koenke & Otto, 1969; Haring & Fry, 1979; Hayes & Readence, 1982). A general explanation of pictures' role in comprehension can be found in prominent twentieth century learning theorists' (Ward, 1920; Koehler, 1929; Bartlett, 1932; Wertheimer, 1945) consensus that visual images serve to organize information and organized information is easier to understand and remember. This is an explanation that has been supported many times by experiments demonstrating that information is more rapidly learned when it is grouped or thematically organized than when it is presented in lists or in isolation.

The findings of comparable performance between subjects of both the literal and the embellished instruction groups is in accord with other research which suggests that given ample context, verbal illustration is

as easily understood as literal presentation (Ortony, et. al., 1978) and that complicated and creative images can be created easily and quickly (Harris, Lahey, & Marsalek, 1980). Since the present results show comparable results on immediate task performance for both text groups--literal and embellished--evidence cannot be offered on either side of the long-standing controversy as to whether images evoked in reading are immediately cognized as percept-like or concept-like representations (Downey, 1919; Verbrugge, 1977; Paivio, 1979).

The memory data are perhaps more informative on this question. If pictorial illustrations are represented in memory as reconstituted percepts, they should serve for remembering instructions as well as for clarifying them in the first place. Certainly, if they provide significantly better access to the details of a task than verbal illustration when the instructions are initially available, they should be relatively no less helpful when the instructions are not at hand and have to be remembered. The results of the experiment show instead that memory of the fanciful circumstance associated with the procedures far outweighed memory of the pictorial illustrations.

This finding suggests that images useful for successfully completing the memory task were represented in memory rather more propositionally than visually and that thus represented served rather more as integral constituents in recollection processes than as visual prompts for conjuring chains of verbal, then in turn, cognitive and manipulative responses.

Researchers consistently find that metaphorical presentations of unfamiliar material are better remembered than literal presentations (e.g. Pearson, Raphael, TePaske, & Hyser, 1979; Reichmann, 1977; Reynolds,

Schwartz, & Esposito, 1982), partly because of the power of a metaphor's vehicle to explain and make meaningful its topic by specifying familiar reference points and the relations between them (Ortony, 1975; Petrie, 1980; Sticht, 1980), but also because metaphor comprehension requires encoding that fuses disparate semantic domains and thereby sets up a rich matrix of meaning that is useful for retrieval in remembering (Harris, Lahey, & Marsalek, 1980).

In light of the extensive use of illustrated procedural instructions, there is a decided need to further investigate the effects of pictorial and verbal elaboration on both initial learning and long-term retention. This research should address critical performance variables including the nature and complexity of the task itself, the form, arrangement, presentation mode, and informativeness of the pictorial and verbal illustrations, and the numerous potential interactions made possible by systematically combining these factors. In particular, it may be revealing to analyze the respective contributions of narrative and illustrative information when both are readily available to the learner. It would also be useful to explore in greater detail why and how learners activate certain facilitating strategies when confronted by demanding procedural tasks. Related to all these issues, there is a justifiable rationale for determining if developmental differences exist over like learning tasks for varying cognitive stages, and if so, specifying the nature and magnitude of these differences.

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Table 2

ANOVA Summary of Knot-tying Manipulations Achieved from Written Instructions

Source	df	SS	MS	F
Type of Text (A)	1	.0089	.0089	<1
Picture (B)	3	87.8125	29.2708	10.30*
A X B	3	5.2411	1.7470	<1
Within	104	295.5	2.8413	
Total	111	388.5625		

Table 1

Means and Standard Deviations[a] of Knot-tying Manipulations Achieved from Written Instructions

	Presentation[b]			
	Literal		Analogical	
No Pictures	.642	(1.008)	.571	(.852)
Functional	2.710	(2.164)	3.214	(1.929)
Expressive	2.500	(1.605)	1.857	(1.875)
Functional + Expressive	2.357	(1.946)	2.643	(1.646)

[a]Standard deviations are in parentheses

[b]n = 14 each Presentation x Picture condition